PB-251 758

DESIGN AND OPERATING PARAMETERS FOR EMISSION CONTROL STUDIES: MAGMA, SAN MANUEL, COPPER SMELTER

I. J. Weisenberg, et al

Pacific Environmental Services,
Incorporated

Prepared for:

Industrial Environmental Research
Laboratory

February 1976

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170154

EPA-600/2-76-036e
February 1976

PB 251 758
Environmental Protection Technology Series

[illegible] OPERATING AMMETERS FOR [illegible] CONTROL STATES: [illegible] Manual, Copper Smelter

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TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-600/2-76-036e		

4. TITLE AND SUBTITLE	5. REPORT DATE
Design and Operating Parameters for Emission Control Studies: Magma, San Manuel, Copper Smelter	February 1976
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
I.J. Weisenberg and J.C. Serne	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
Pacific Environmental Services, Inc. 1930 14th Street Santa Monica, CA 90404	1AB013; ROAP 21ADC-061
	11. CONTRACT/GRANT NO.
	68-02-1405, Task 5
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
EPA, Office of Research and Development Industrial Environmental Research Laboratory Research Triangle Park, NC 27711	Task Final; 4-10/75
	14. SPONSORING AGENCY CODE
	EPA-ORD

15. SUPPLEMENTARY NOTES

EPA Task Officer for this report is R. Rovang, 919/549-8411, Ext 2557.

16. ABSTRACT The report gives background design data for a specific copper smelter. The data is sufficiently detailed to allow air pollution control system engineering studies to be conducted. These studies will be concerned primarily with lean SO2 streams that currently are not being captured. Physical layout of the smelter and the surrounding area is presented, along with existing control equipment. Ductwork that would be considered for future system tie-in is defined. Emissions from operating equipment, gas flow rates, temperatures, sulfur balance, and a process flow sheet are included. Utilities, stack dimensions, footing requirements, and solid waste handling are defined. Available area for new control equipment, gas characteristic variation, and potential new control equipment installation problems are discussed.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution	Air Pollution Control	13B
Copper	Stationary Sources	07B
Smelters	Emission Control	11F
Design	Operating Data	
Sulfur Dioxide	Solid Waste Handling	
Utilities	Wastes	

PRICES SUBJECT TO CHANGE

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
Unlimited	Unclassified	29
	20. SECURITY CLASS (This page)	22. PRICE
	Unclassified	4.00-2.25

EPA-600/2-76-036e
February 1976

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by

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Contract No. 68-02-1405, Task 5
ROAP No. 21ADC-061
Program Element No. 1AB013

EPA Project Officer: R. D. Rovang

Industrial Environmental Research Laboratory
Office of Energy, Minerals, and Industry
Research Triangle Park, NC 27711

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
Washington, DC 20460

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THE FIGURES IN THIS DOCUMENT ARE NONREPRODUCIBLE, THEREFORE ARE EXCLUDED FROM THIS REPORT.

A. INTRODUCTION AND SUMMARY

The purpose of this report is to present background design data on the Magma Copper Company Smelter, San Manuel Division at San Manuel Arizona in sufficient detail to allow air pollution control system engineering studies to be conducted. These studies are primarily concerned with lean SO_2 streams that are currently not being captured.

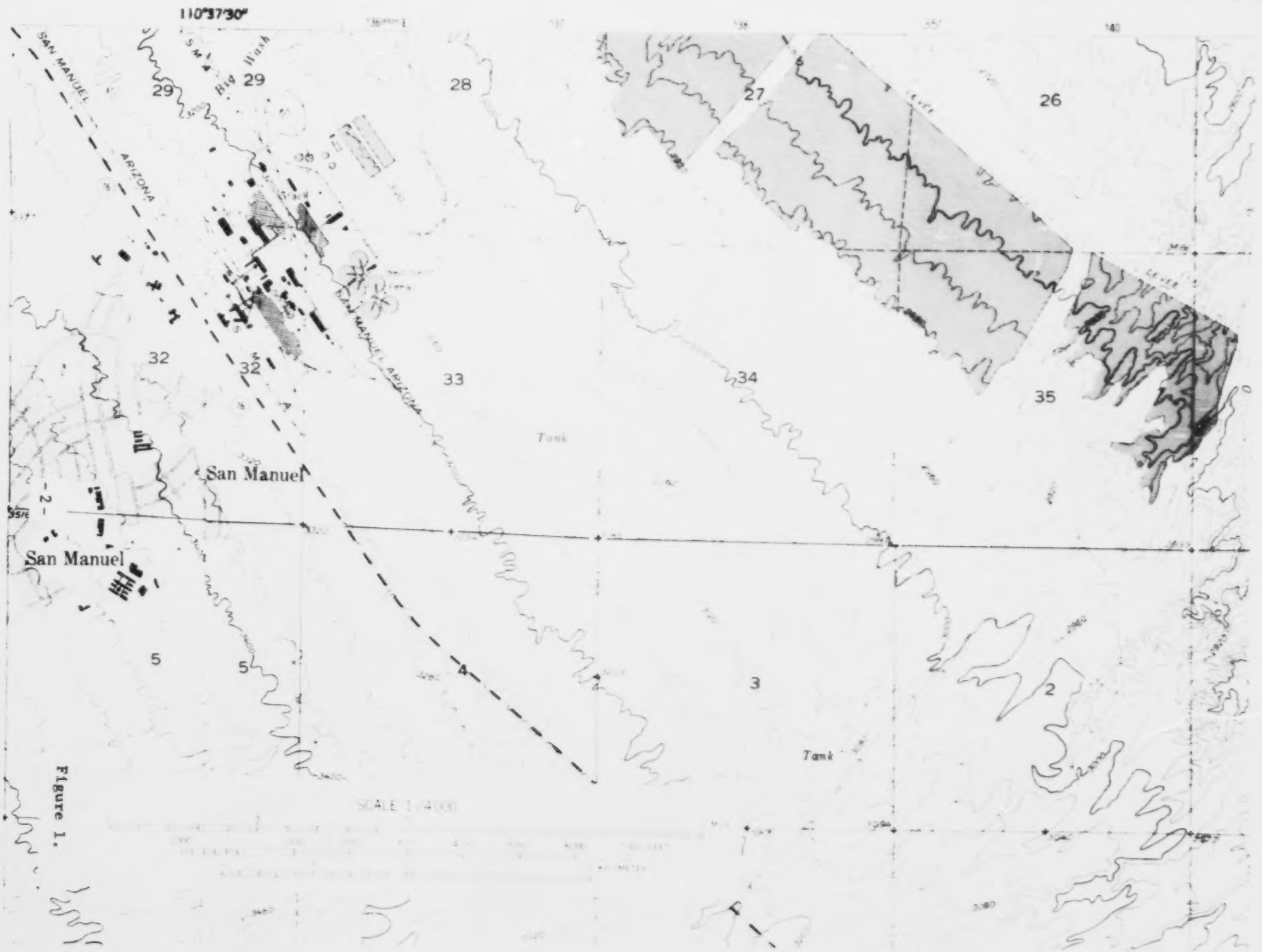
Physical layout of the plant and surrounding area along with existing smelter and control equipment is presented. Ductwork that would be considered for future system tie-in is defined. Emissions from operating equipment, gas flow rates, temperatures, sulfur balance and process flow sheet are included. Utilities, stack dimensions, footing requirements and solid waste handling are defined. Available area for new control equipment, gas characteristic variation and potential new control equipment installation problems are discussed.

The major uncontrolled source of SO_2 at this smelter are the three reverberatory furnaces with approximately 92,000 tons per year of SO_2 and 570 tons per year of particulate. There appears to be some additional space for new control equipment within the smelter area but not necessarily adjacent to the emitting equipment.

B. PLANT LOCATION ACCESS AND OVERALL GENERAL ARRANGEMENT

The Magma Copper Company Smelter is located to the northeast and adjacent to the town of San Manuel, Arizona. A portion of the USGS map showing land contours of the immediate area is presented in Figure 1. Design altitude for the plant is 3,200 feet with latitude 32^{o} 37' and longitude 110^{o} 37'.

The overall plant and smelter general arrangement are shown in Figure 2. The primary particulate emission sources are the crushing and screening operations and the reverberatory furnaces and converters. The primary sources of sulfur dioxide are the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34
35
5
4
3
2

Figure 1.

Figure 2

OVERALL PLANT AND GENERAL ARRANGEMENT

(Located in Pocket Inside Back Cover)

reverberatory furnaces and converters. Ore source is from the local San Manuel Mine, an underground mine. Additional concentrate feed is obtained from outside sources.

The Magma San Manuel smelter consists of three reverberatory furnaces with six converters. A seventh converter may be added at a later date if the need is indicated. The output from the converters is taken to the anode furnaces which supply the casting wheels for casting the anodes. Figure 3 is a smelter flow sheet schematic. (Ref. 1)

The pollution control equipment consists of electrostatic precipitators for cleaning the offgases from the reverberatory furnaces and additional electrostatic precipitators for cleaning the offgases from the converters. No SO_2 control of the reverberatory furnace offgases is accomplished. A 2,400 ton per day single contact sulfuric acid plant collecting SO_2 from the converter offgases was recently started up. In addition, a separate system has been established to neutralize the liquid effluent from the scrubber and other acid plant sources.

Figure 2 showing the overall plant site indicates space for new control equipment could be found to the northwest of the smelter building. The area southeast of the smelter building could be used if an alternate area for emergency concentrate storage could be established.

C. PROCESS DESCRIPTION

The smelter flow sheet diagram is shown in Figure 4. The feed in the form of precipitates, concentrate, lime, flux, and flue dust is fed to one of the three reverberatory furnaces. Matte is produced in the reverberatory furnaces and is passed to one of the six converters which produce blister copper for further refining in the anode furnace. Copper from the anode furnace is then used to cast anodes. Gases from the reverberatory furnace pass through waste heat boilers, electrostatic precipitators and then out the stack. Gases from the converters pass

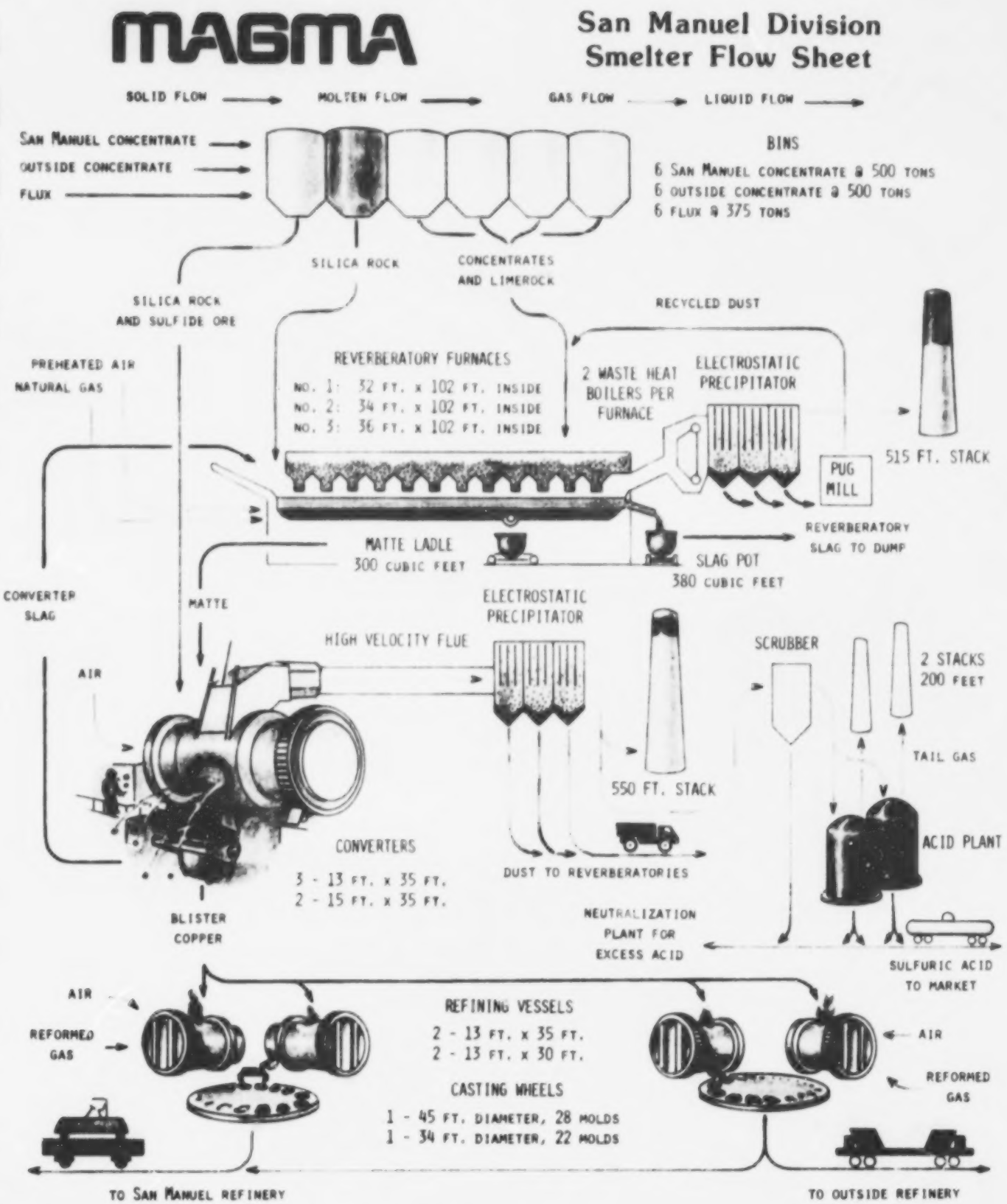
MAGMA
San Manuel Division
Smelter Flow Sheet
SOLID FLOW
MOLTEN FLOW
GAS FLOW
LIQUID FLOW
San Manuel Concentrate
Outside Concentrate
Flux
BINS
6 San Manuel Concentrate @ 500 tons
6 Outside Concentrate @ 500 tons
6 Flux @ 375 tons
Silica Rock
Concentrates and Limerock
Silica Rock and Sulfide Ore
Recycled Dust
Preheated Air
Natural Gas
Reverberatory Furnaces
No. 1: 32 ft. x 102 ft. Inside
No. 2: 34 ft. x 102 ft. Inside
No. 3: 36 ft. x 102 ft. Inside
2 Waste Heat Boilers per Furnace
Electrostatic Precipitator
515 ft. Stack
Pug Mill
Reverberatory Slag to Dump
Matte Ladle
300 cubic feet
Slag Pot
380 cubic feet
Converter Slag
Matte
Electrostatic Precipitator
High Velocity Flue
Scrubber
2 Stacks
200 feet
Air
550 ft. Stack
Tail Gas
Converters
3 - 13 ft. x 35 ft.
2 - 15 ft. x 35 ft.
Acid Plant
Dust to Reverberatories
Blister Copper
Neutralization Plant for Excess Acid
Sulfuric Acid to Market
Air
Reformed Gas
Refining Vessels
2 - 13 ft. x 35 ft.
2 - 13 ft. x 30 ft.
Casting Wheels
1 - 45 ft. diameter, 28 molds
1 - 34 ft. diameter, 22 molds
Air
Reformed Gas
To San Manuel Refinery
To Outside Refinery

Figure 3

Process Flow & Sulfur Balance Sheet

Magma Copper Co / San Manuel — Nov. 1975

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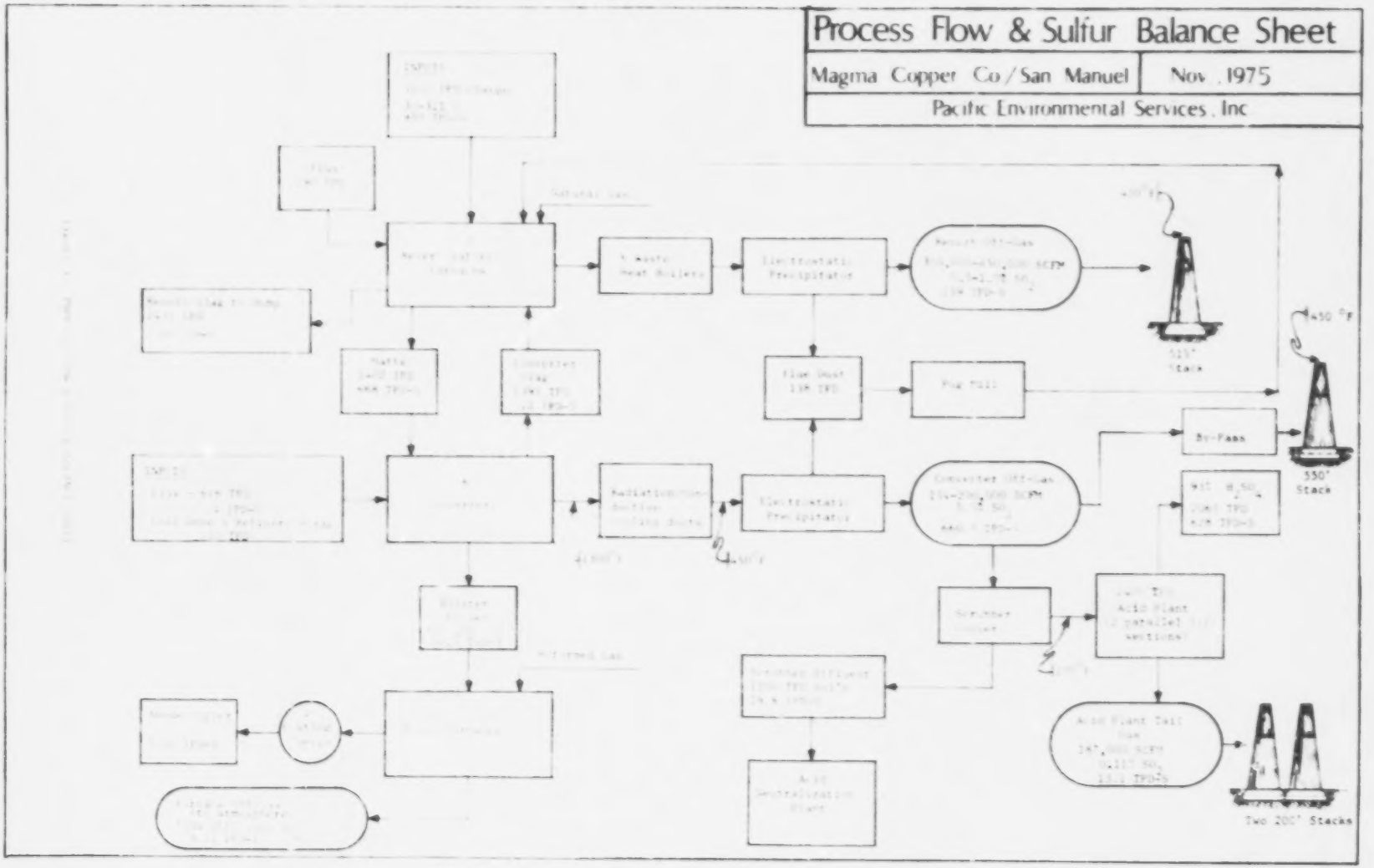

through water cooled hoods to electrostatic precipitators, then to scrubbing towers, mist precipitators and finally a Monsanto single contact acid plant.

Temperatures, volume flows, and SO_2 percentages are shown on the flow sheet.

D. EMITTING EQUIPMENT

a. Reverberatory Furnaces

The initial copper concentrate containing approximately 28% copper is fed to three natural gas or oil fired top charged reverberatory furnaces all 102 feet long by 32 feet, 34 feet and 36 feet wide respectively. The reverberatory furnaces have suspended roofs with sealing materials such as ceramic fiber, mud or asbestos packed along the joint. The roof is anchored with tie rods suspended from the ceiling.

Magma normally operates three reverberatory furnaces at full capacity at all times. The reverberatory furnaces are fed from the top along the front 60% of the furnace side walls. Two air preheaters capable of operating on either No. 2 fuel oil or natural gas are used to preheat the air going to the reverberatory furnace burners. This allows an increase in the gas temperature and also combustion efficiency. It is necessary to have at least 60% fire to the reverberatory furnace to maintain temperature. A five year campaign is presently being conducted on the furnaces before reworking is required. The processes occurring within the reverberatory furnace are controlled by adjusting draft, fuel input, fuel air ratio, and feed scheduling.

b. Converters

The matte produced by the reverberatory furnace containing 32 to 35% copper is processed in three 13 foot by 35 foot and three 15 foot

by 35 foot Peirce-Smith type converters. Converter slag is returned to the reverberatory furnace and blister copper is delivered to four anode holding furnaces.

The 15 foot by 35 foot converters use an air supply varying from 30,000 to 45,000 SCFM. Scheduling of the converters to maintain a more or less constant flow of SO_2 to the acid plant is attempted. A single charge will remain in the converter for a period of about twelve hours. There are four or more slag blows of about 1½ hours each and one finish blow. Oxygen has been used at a rate of up to 30 TPD at times in converter blowing air to increase the heat available allowing cold dope addition.

c. Other Emitting Equipment

Material handling in the feed preparation area during crushing and screening operations generates particulate. The anode/refining furnace generates small quantities of SO_2 and particulate.

Leaks in ducts and at other pieces of equipment can release SO_2 and particulate. Ladles holding matte and slag will produce visible fugitive emissions.

The acid plant will also produce SO_2 emissions.

E. EXISTING CONTROL EQUIPMENT

Gases from the three reverberatory furnaces, after passing through the waste heat boilers, are combined and enter an electrostatic precipitator. Gases from the precipitator then pass directly to the 515 foot reverberatory furnace stack. Dust from the precipitator is combined with lime and is processed in a pug mill and returned to the reverberatory furnace feed.

Gases from the converters enter water cooled hoods over each converter. The gases are then ducted together and enter a radiation/conduction cooler which simply consists of a duct sized to provide

7,000 FPM gas velocity. Total gas flow from the converters to the acid plant varies from 154,000 to 200,000 SCFM. At this range of flow the gases are cooled from an inlet temperature of 1200°F down to 400°F to 500°F at the outlet of the cooler. They then pass into a precipitator which removes a major portion of the particulate matter.

The converter gases then go to a 2,400 TPD sulfuric acid plant. The gases average 5.5% SO_2. The Monsanto single contact acid plant was completed in January, 1975 and is currently in operation. It is designed to be converted to double contact. The gases are further cleaned, after going through the precipitator, by passing to one unpacked and one packed cooling tower that have weak acid flowing through to provide humidification and cooling. From the packed towers the gas, which will be at a maximum temperature of 140°F and will average 100°F, passes to six mist precipitators in a parallel series circuit. From the mist precipitators, the gas is passed to the dryer where the moisture is absorbed in concentrated acid. The gas is then passed through demisters and on into the SO_2 to SO_3 converter which has four conventional stages with three inner stage heat exchangers that use incoming gas to cool the outgoing gas.

One special feature of this plant is that there are two parallel trains starting downstream of the packed cooling tower and following through to the end of the acid plant. This design allows shut down of one side for maintenance while the other side continues to operate.

In addition, each side has a preheater that is designed to "float" on line. The preheater controls the gas temperature into the first pass of the converter. If the concentration of SO_2 in the gas stream is too low, for example, for autogenous operation, the burner will immediately and automatically turn up providing additional heat for efficient conversion. The burner is semi-automatic and will stop and start on the temperature signal from the converters.

Carbate heat exchangers are used for cooling the weak acid. In addition, Teflon "spaghetti" coolers are used for cooling the strong

product acid. An air cooled evaporation cooling tower is used to cool all process cooling water.

Fiberglass reinforced plastic (FRP) is used for ductwork throughout to handle the wet SO_2 laden gases up to the dryer. There are three main blowers for the process gas system with one being used as a standby unit. Each blower has a 6,000 horsepower motor and individual pressurized lubrication system.

A neutralization plant is available to neutralize excess acid produced. This plant uses the concentrate tailings since they are basic and have a major portion of the material necessary to neutralize the acid. When total acid to be neutralized exceeds the quantity the basic mill tails can neutralize, lime rock slurry must be added. The neutralization system is used when the total amount of acid produced cannot be sold or exceeds storage capacity. Up to 800 TPD has been neutralized.

F. GAS SYSTEM DUCTWORK

Sufficient information was not obtained from the smelter to define ductwork.

G. SULFUR BALANCE AND GAS COMPOSITION AT SYSTEM EXIT

1. Maximum Sulfur Balance Data Based on Enlarged Capacity Of 1,125,000 Tons of Concentrate Per Year Based on Data From Smelter (Reference 2)

	TPD
Sulfur Input	954
Sulfur Emitted by Reverberatory Furnaces	259
Sulfur Emitted by Converters	660.9
Sulfur Removed in Slag	34.0
Sulfur Removed in Blister Copper	.15
Sulfur Fixed	
Acid Plant	647.8
Slag and Solid Waste	34.0
	681.8
Sulfur Fixed 71.5%	

2. Sulfur Balance Data For August 1973 Through July 1974 Based On Average Production Of 750,000 Tons Concentrate Per Year (Reference 3)

32.07% sulfur in concentrate, average (660 TPD)

Sulfur lost:	TPD	% of Total Sulfur
In slag	23.97	3.630%
In blister copper	0.10	0.015%
In reverb gas	181.59	27.505%
In converter gas	454.55	68.850%
	660.21 total	100.000% total

Sulfur lost in fugitive emissions: less than 2.5% of total sulfur, or less than 16.5 TPD

Sulfur lost in acid plant sludge: not applicable

Sulfur converted to H_2SO_4: not applicable

Sulfur emitted from reverberatory furnaces: 181.59 TPD

Sulfur emitted from roasters: not applicable

Sulfur emitted from converters: 454.55 TPD

3. Reverberatory Flue Gas Analysis (Reference 4)

SO_2	0.7 - 1.0%
CO_2	8.3%
N_2	69.71%
H_2O	19.24%
O_2	10-15%

4. Converter Flue Gas Analysis During Slag Blow (Reference 4)

SO_2	9-10%
N_2	82.27%
O_2	10.65%

5. Converter Flue Gas Analysis During Finish Blow (Reference 4)

SO_2	13-14%
N_2	79.14%
O_2	10.43%

6. Range of Converter Gas Constituents

Constituent	Percent Range
SO_2	5.0 to 14.0
SO_3	.15 to .16
O_2	8.6 to 12.9
N_2	78.75 to 82.27
H_2O	0 to 2.6

Traces of chlorine, fluorine, arsenic, antimony, bismuth s lenium, chromium, zinc, and lead with maximum dust loading of 0.5 grains per SCF.

Trace Element Range

Chlorides or Chlorine	10-30 ppm b.v.
Fluorine or Fluorides	25-50 ppm b.v.

7. Gas Reformer Gas (Reference 4)

Combustion Products - CO_2, H_2O

Process Gas - H_2, CO, CO_2, N_2

Reformer gas is used to provide a reducing atmosphere for final refining in anode furnace.

The anode furnace generates combustion products which go to the atmosphere with a negligible SO_2 concentration and primarily CO_2 and H_2O. This is also true for the air preheater.

8. Particulate Analysis

Copper (as CuO)	10-15% b.w.
Iron (mostly $Fe_2(SO_4)_3$)	10-20% b.w.
Arsenic	.04 - 0.6% b.w.
Selenium	.03 - 0.5% b.w.
Tellurium	.005 - .01% b.w.

9. Particulate Analysis (Reference 5)

Compound	Average % b.w.
Copper	18.3%
Iron	11.2%
Sulfur	12.13%
SiO_2	4.9%
CaO	1.05%
Al_2O_3	0.39%
Zn	9.4%
Pb	2.5%
Trace Elements	L.T. 2%

H. GAS CHARACTERISTIC VARIATION

The SO_2 concentrations in the offgas from the reverberatory furnace will vary significantly depending upon the charge rate and the various sulfide materials contained in the charge. The normal or average charge rate into the furnace can vary as much as 4 to 1 over a period of time. This variation is a result of normal smelter operation and can be controlled only to a limited extent.

SO_2 concentration in the converter offgas also varies considerably because of the batch nature of the operation. Also, the variation in actual metallurgical operation between slag blows and copper blows will cause a variation in percent SO_2. (See Section G). Between blows the converter may be rolled out for slag pouring or material charging.

The attempt is always made to maintain at least two converters blowing gases into the system at any given time. Usually a converter will be provided with 18,000 to 20,000 SCFM to the tuyeres. An additional 100-120% of dilution air is generally estimated to be added to this gas flow resulting in a total gas flow from each converter in the range of 35,000 - 45,000 SCFM. Thus, the gas volume from the converter line to the control system acid plant and liquid SO_2 plant can vary over a wide range from maximum to zero.

I. STACK DESCRIPTION

Reverberatory Furnace Stack

Height 515 feet
Inside diameter 20.8 feet (top)
Inside diameter 30 feet (base)
Gas exit temperature 450 - 500° Fahrenheit
Acid brick lined
Draft at Base 2.6" w.c.

Converter Stack

Stack height 550 feet

Inside diameter 20.0 feet (top)

Exit temperature 450 - 500° Fahrenheit

Draft -2.5" W.C.

Acid Plant Stacks (2)

Height 250 feet

Diameter 10 feet

Draft (forced) +10.0" W.C.

Steel

J. PRESENT TECHNIQUE FOR SOLID WASTE HANDLING

Slag from the reverberatory furnaces is taken by ladle car to the dump. Dust from the reverberatory furnace gas precipitator is treated in a pug mill and then recycled through the bedding plant and added to furnace feed. Dust from the converter gas precipitator is taken by truck to the bedding plant for recycle to the furnace.

K. FOOTING AND STRUCTURAL REQUIREMENTS

Seismic zone 2 and wind load 20 PSF are used for design. Ambient temperature range is 110°F to -20°F.

L. EXISTING AND POTENTIALLY AVAILABLE UTILITIES

Water is supplied from wells. It can be expected that future supplies of fuel gas in this area will be limited. Plans for handling and burning coal are currently being formulated. Electricity should be sufficiently abundant for most control requirements with the possible exception of use of an electric furnace to replace the reverberatory furnace.

M. POTENTIAL NEW CONTROL EQUIPMENT PROBLEMS

The variation of emissions could limit control system effectiveness. It appears that the area adjacent to the smelter is sufficient to allow installation of new control systems.

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